Docket No.: 2003P15333

CERTIFICATION

I, the below named translator, hereby declare that: my name and post office address are as stated below; that I am knowledgeable in the English and German languages, and that I believe that the attached text is a true and complete translation of PCT/EP2004/053184 of November 30, 2004.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Description

Method for the automatic starting and stopping of an internal combustion engine

The invention relates to a method for the automatic starting and stopping of an internal combustion engine of a motor vehicle by means of a start-stop device according to the preamble of claim 1.

Such a method is known from DE 102 11 461 C1. There, it is proposed that, after the internal combustion engine has been started by a driver, said engine be stopped automatically depending on multiple stop conditions. One of these stop conditions is the release of the stop mode of an air-conditioning device, its release being in turn dependent on, among other things, a temperature measured in the interior of the motor vehicle. The condition in respect of the value of this measured temperature is that it lie within an acceptable tolerance range.

A further stop condition, which must be present as an AND function linked to the other stop conditions, is a variable delay period which delays the release of the stop mode, i.e. the switching off of the internal combustion engine. This is designed to prevent unwanted automatic switching off e.g. when maneuvering or when stopping briefly to turn in the face of oncoming traffic.

In vehicles fitted with automatic start-stop technology, there is always the problem that when the internal combustion engine is switched off the air-conditioning system cannot be operated, as the air-conditioning compressor in the auxiliary

unit drive is also not running. As a solution to this problem, the internal combustion engine could, where there is a request for air-conditioning, not be switched off at all, but this has disadvantages in terms of fuel consumption. Similarly, it would be possible to disconnect the air-conditioning compressor from the usual auxiliary unit drive and to drive it separately electrically, but this is cost-intensive and can place excessive strain on the vehicle electrical system. The electrical drive could in this case also be a starter-generator that drives the auxiliary units via a belt, a clutch then being necessary between crankshaft and auxiliary unit drive.

Against this background, the object of the invention is therefore to indicate a method that provides a favorable (in terms of fuel consumption) mode of operation for the start-stop operation of an internal combustion engine, while at the same time being more convenient for the driver.

The achievement of this object will emerge from the features of claim 1, while advantageous embodiments and further developments of the invention will be indicated in the dependent claims.

Accordingly, the invention relates to a method for automatically starting and stopping an internal combustion engine of a motor vehicle by means of a start-stop device, by means of which the internal combustion engine, having been started by a driver, is switched off automatically depending on multiple stop conditions, one of the stop conditions being the release of the stop mode of an air-conditioning device depending on, among other things, a temperature prevailing in the interior of the vehicle, and a further stop condition

being the expiration of a defined variable time period, this time period depending on the temperature difference between the temperature prevailing in the interior and the target temperature desired by the driver.

A further feature of the invention is characterized in that the time period depends on the air-conditioning performance of the air-conditioning device, that is e.g. on the cooling performance of the air-conditioning compressor.

Moreover, it is advantageous if this time period depends on the relative air-conditioning performance, this relative air-conditioning performance being the quotient of the air-conditioning performance of the air-conditioning device and the temperature difference.

In another embodiment of the invention, it can be provided that the end of the specified time period depends on a basic value of a threshold value, this basic value being read out from an engine characteristics map depending on the relative air-conditioning performance. An engine characteristics map is in this context optionally also understood to be just a single curve trace that reproduces the course of one variable depending on another variable.

A further feature of the invention is characterized in that the threshold value is calculated from a link between the basic value and a learning factor, the learning factor representing a driver-specific manner of driving.

In addition, it is advantageous if, when air conditioning is requested by the driver and the internal combustion engine is not running, this air conditioning request starts a timer

that sets a start time of the time period, and the end of the time period is determined by a comparison of the current value of the timer with the threshold value, whose value is dependent on the temperature difference. It can be provided here that the starting of the timer sets a logic marker.

It is also an integral part of the invention that, when there is a request for air conditioning by the driver and the internal combustion engine is running, the value of the timer is compared incrementally with the threshold value, and where the threshold value is exceeded by the current value of the timer, release of the stop mode of the air-conditioning device is enabled.

Use of the method according to the invention advantageously dispenses fully with the need for additional mechanical components for solving the problem indicated. The procedures provided provide rather for modeling of the operating behavior of the air-conditioning device and of the temperature measured and/or calculated in the interior of the vehicle.

The methodological procedure according to the invention determines to this end whether stopping of the internal combustion engine at the time desired by the driver is possible from an air-conditioning point of view. Only if too great a temperature difference prevails is a release of stop mode not granted, rather the internal combustion engine then continues to run for a defined period until this temperature difference has reached a value that ensures that the interior feels comfortable for the driver.

The proposed method permits in an analogous manner control of an air-conditioning-related restart of the internal combustion engine.

The method according to the invention uses at least one interior temperature T_ist, which is measured or calculated in accordance with a temperature model.

A physical/mathematical temperature model of the vehicle interior is preferably used for calculating the interior temperature T_ist, which model takes into account a plurality of variables which represent the inflow and outflow of heat energy in the vehicle interior under different vehicle operating conditions.

The variables taken into account by the temperature model include for example the geometry and the size of the vehicle interior, its thermal insulation properties, the surface area of the windows, the number and electrical rating of electrical consumers located in the vehicle interior which are switched on, the thermal input from solar irradiation and the thermal input from an interior heating and ventilation device.

Finally, it can be provided that multiple interior-related target temperatures (T_soll) and interior temperatures (T_ist) are determined or taken into account when the method is implemented.

To illustrate the invention, enclosed with the description are drawings, with the aid of which an exemplary embodiment, together with further features and advantages, is explained in detail below, and in which:

Fig. 1 shows a schematic overview of the system according to the invention,

Fig. 2 shows the flow diagram of a program which is executed in the system overview according to Figure 1, and

Fig. 3 shows the flow diagram of a further program which determines a value that is processed in the program according to Figure 2.

A drive train of a motor vehicle has an internal combustion engine 1 to which an electronic engine control unit 2 is assigned. The crankshaft of the internal combustion engine 1 is connected either directly or via a belt to a starter-generator 3, and is also connected via a clutch 4 to a gear unit 5 which acts upon the wheels 6 of the motor vehicle.

The clutch 4 can be a friction clutch or a converter-bypass clutch. A shared control unit 7 is assigned to the clutch 4 and the gear unit 5 and a control unit 8 to the starter-generator 3.

An air-conditioning device 10 is assigned to an interior 9 of the motor vehicle, which air-conditioning device comprises among other things an air conditioner 22 and a blower. A temperature sensor 11 in the interior 9 records the temperature T_ist currently prevailing in the interior 9.

A system-wide drive train management system 12 processes a plurality of incoming information items and also forwards a plurality of signals and/or information items to various components. In this way it receives via lines 13, 14 and 23 sensor signals which transmit the wishes of the driver with

regard to actuation of an accelerator pedal 15, a gear selection lever 16 and a brake pedal 24. Further signals are fed to the drive train management system 12 from sensors or regulating units combined under a single symbol into a block 17. For example, a signal is transmitted via a line 18 which transmits the switching-off or switching-on request made by the driver with regard to the air-conditioning device 10. A further line 19 transmits the target temperature value T_soll for the interior 9 input by the driver personally via a corresponding operator panel.

The control units 2, 7 and 8 can be combined with one another and/or be an integral component of the drive train management system 12; equally, said drive train management system can be distributed between the control units 2, 7 and 8.

Forming part of the drive train management system 12 are a start-stop device 20 and an evaluation circuit 21. Inside the start-stop device 20, among other things a program is executed which is explained in detail in connection with Figure 2. The evaluation circuit 21 contains a program which is explained in detail in connection with Figure 3.

The drive train management system 12 ensures that, depending on defined conditions, the internal combustion engine 1 is stopped or started in an automatic manner, without the person driving the vehicle having to intervene separately for this purpose. One of the conditions which has to be complied with in order for the start-stop device 20 of the drive train management system 12 to permit stopping is the release of this start-stop mode by the air-conditioning device 10.

The program running in the start-stop device will now be explained with the aid of the flow diagram in Figure 2.

In a step S1, the request of the driver with regard to the switching on of the air-conditioning device 10, which is transmitted via the line 18, is input. In the event that operation of the air conditioner is not desired, in a step S2 a resettable time counter (timer T1), to be explained later, is reset in a step S3 via the output "no". Moreover, the immediate release of the start-stop mode for the internal combustion engine 1 is effected in a step S4, provided also that the other conditions for this, which will not be explained in detail here, are fulfilled.

If in step S2 operation of the air conditioner is desired (output "yes"), then in a step S5 it is determined whether the start-stop device 20 is currently active, that is, the internal combustion engine 1 is switched off. If this is the case (output "yes"), then in a step S6 a query is made as to whether a marker M1 has already been set. If this is not the case (output "no"), then in step S7 the timer T1 is started and in a step S8 the marker M1 is set.

The timer T1 gives the time since the last activation event, that is, since the air-conditioning device 10 was switched on by the driver or by starting the internal combustion engine 1. The start time of the timer T1 defines here a start time of a time window delta_t, which is open until such time as the timer T1 is stopped.

The marker M1 is a logical state variable, which is reset when the air-conditioning device 10 is switched off by the driver or when the internal combustion engine 1 is started.

If in step S6 the marker M1 was already set, i.e. output "yes" from step S6, then release of the start-stop mode by the air-conditioning device 10 is granted in step S4.

If the marker M1 was set in step S8, then in a step S9 the current value of the timer T1 is compared with a threshold value SW.

Determination of this threshold value (SW) will be explained in detail later in connection with Figure 2.

If in step S9 the value of T1 lies above the threshold value SW (output "yes") then in step S3, the timer T1 is reset to the value zero and release granted in step S4. If it lies below the threshold value SW, output "no" from step S9, then start-stop mode is blocked in a step S10.

In the event that the start-stop device 20 is currently not active, i.e. the internal combustion engine 1 is running, a query is made in step S11, via the output "no" from step S5, as to whether the timer T1 has already started. If this is not the case (output "no"), then further execution of the program takes place with the aid of the previously explained steps S6, S7, S8 and S9.

If the timer T1 should already have started, output "yes" from step S11, then the value of the timer T1 is incremented in a step S12 and each increment is then compared in the previously explained step S9 with the threshold value SW.

The method described previously is executed e.g. in a time cycle of 10 milliseconds and the logical release variable

which is output as a result via step S4 or S10 is transferred to the drive train management system 12.

Determination of the threshold value SW will be explained in detail below with the aid of Figure 3.

The air-conditioning device 10 makes various items of information available via an interface 30 of a CAN bus. For example, via paths 32, 34, 36, 38 and 40 the value of the external temperature currently recorded via a sensor (not shown), the target temperature value for the interior of the vehicle T_soll input by the driver via an operator panel in the interior 9, the current actual temperature value T_ist in the interior 9 determined via the sensor 11, the difference delta_T of these two stated temperature values (T_soll less T_ist), and the adjusted performance of the air-conditioning device 10, i.e. the cooling or heating performance, are transferred to a step S9.1.

In this step S9.1, a relative air-conditioning performance p_klima_rel is calculated with the aid of the existing information as a quotient from the value of the cooling performance in watts and the temperature difference delta_T in degrees Celsius. The value of this relative cooling performance P_klima_rel is fed in a step S9.2 to an engine characteristics map which, depending on this value, reads out basic values GW in seconds. Some typical value pairs from this engine characteristics map, which can consist of a so-called look-up table, are given by way of example in the table below:

P_klima_rel (Watts/degrees Celsius)	Basic value GW
- 500	

(seconds)	
- 120	60
- 200	30
-100	0
0	30
100	60
200	120
500	

In a step S9.3, this basic value GW is then linked multiplicatively with a learning factor L1. This learning factor L1 can assume values between zero and one and enables adaptation of vehicle behavior to particular driver requests and driving methods.

Finally, in a step S9.4, the threshold value SW is output as a mathematical product of the basic value GW and the learning factor L1 and transferred to step S9, which is explained with the aid of Figure 2.